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ANALYSIS AND OPTIMIZATION OF GLASS FIBER WITH EPOXY RESIN COMPOSITE LEAF SPRING USED IN CARS

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ABSTRACT

A leaf spring made up of steel, used in the back suspension system of the smaller passenger vehicle like car, is analyzed using analyzing software (ANSYS). By using the finite element analysis response, the stress induced and deflections occurred are substantiated in the analysis software. Using the results and dimensions of the existing leaf spring made of steel, a composite leaf spring made up of glass fiber with epoxy resin is modeled and optimization is performed in the ANSYS analyzing software. The main contemplation is given to optimizing the geometry of the leaf spring. The main objective is to examine the load bearing capacity, stiffness and the weight reduction of composite leaf spring with the leaf spring made of steel. From the result, it is evident that the optimum leaf spring width decreases exaggeratedly and the thickness increases straightly from the spring eyes to the axle seat of the spring. Compared to the leaf spring made of steel, the optimized composite leaf spring has much lower stresses and the weight of the spring without eye and its unit is nearly 79% lower.

***KEYWORDS:** Composites, Leaf Spring, Steel, Fiberglass, Epoxy & Optimization*

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Original Article

1. INTRODUCTION

Leaf spring is made of steel that is used on the back and front axle of as car. The leaf spring absorbs the shock load acting on the vehicle. In steel leaf spring, the weight is comparatively more. Presently, composite materials are preferred widely in the automotive industries to replace the metal parts for improved performance. In these present trends, the automobile manufacturers' main focus is on weight reduction of the vehicle. In the present scenario, low fuel consumption, less weight of the vehicle, impressive utilization of natural resources are the main focus of the automobile manufacturers. By introducing the better design concept, the above mentioned can be achieved for the amended material and efficient manufacturing process. The steel leaf springs have many advantages such as good load bearing capacity than others. Compared to advantages of steel leaf spring, the composite leaf spring has very low strength to weight ratio. It is proven that, the weight reduction with enormous stabilization of mechanical properties has made the composites as feasible alternate material for the customary steel. In this current work, the composite leaf spring made of glass fiber epoxy resin is used as alternate for the steel leaf spring. The main contemplation was given to optimizing the geometries of the leaf spring. The main goal was to produce a spring with very low weight, which is capable of bearing given static external loads by some confinement limiting stresses and load displacements. The objective of the fiber reinforced plastics material is to combine the stiffness, strength, corrosion resistance with low density and molding capability. The bulky reinforced

plastics produced today are because of its advantages. Glass fibers are also been used with phenolics, polyvinyl chloride, silicones and polystyrene. These fibers are the best option as reinforcing agents because, of the relative ease with which the high strengths can be grabbed in the fiber with a very few microns in the diameter. Epoxy resins are the most widely used resins and they are organic liquids with very low molecular weight consisting of epoxide groups. The epoxide has three atoms in its circle that is two carbon atoms and one oxygen atom. The reactions of epichlorohydrin with the phenols or the aromatic amines make the highest degree of the epoxies. The hardeners, plasticizers and fillers are added to produce epoxies with a broad range of properties like viscosity, impact, degradation, etc. Even the epoxy polymer is costlier than other polymer matrices; it is the widely used PMC matrix. Epoxy based polymer matrices are used in most of the aerospace applications.

Shokrieh and Rezaei discussed about the dissection and optimization of the composite leaf spring, and a steel leaf spring used in the back suspension of light weight passenger cars was analyzed by the analytical and the finite element analysis methods. The experimental results proved that the analytical and the finite element results are same. The solution proved that the optimum width of the spring reduces exaggeratedly and the thickness of the spring increases straightly from eye towards the axle seat. In the composite leaf spring, the induced stresses are lower than that of the stress induced in the steel spring. The natural frequency is more and the spring weight without eye units is 80% lower than the steel leaf spring [1]. Sancaktar and Gratton discussed about the design and fabrication of a functional composite spring used ina solar powered light vehicle. It is inferred that the redesign of the solar car’s front suspension leaf springs was successful development as it met all design aspects and requirements [2]. Trakakis and Galiotis have discussed about the multifunctional hybrid composites that use carbon and glass fibres oriented into an epoxy matrix. It is inferred that a multifunctional composites consisting of commercial carbon and glass fibre fabrics oriented into an epoxy resin was produced by autoclave curing process. The geometry of the material was cautiously prepared to simulate the bimetallic strip effect during the thermal activation of the spring material [3]. Senthil Kumar and Vijayarangan have discussed about the fatigue and static analysis of the leaf spring made of steel and multi leaf spring made of glass fibre reinforced polymer composite[4]. Colombo and Vergani have discussed about the fatigue design of the structure manufactured in composite materials. In this study, a bus component was considered. Here, the static and fatigue tests were performed on specimens truncated out from the composite beam component along the fibre and the matrix direction, which shows the higher data scattering is in the normal direction of plane [5].Extensive research has been performed in composites materials. Springs are essential suspension elements on automobiles, and it is necessary to reduce the vertical vibrations, impacts and bumps because of road irregularities and to create a comfort ride. Also, to reduce the weight of the vehicle, this contributes fuel consumption. Generally, more stresses will be acting on the leaf spring; in order to reduce the stresses acting on the leaf, spring stress analysis has to be done. Here, leaf spring made of the steel and epoxy composite materials are taken into consideration and optimum leaf spring is chosen, which reduces the stresses acting on it.

2. DESIGN AND ANALYSIS

2.1. Problem Definition

The major problem in the leaf spring is that, stresses acting in it which causes vibration to vehicle body, bumping due to road irregularities and vehicle will wear-out soon due to vibrations. In order to reduce the vibration in the vehicle body, the stresses acting on the leaf spring should reduce. To reduce the stresses acting on the leaf spring, optimum leaf spring has to be chosen. In this study to choose the optimum leaf spring stress analysis has to be carried for steel leaf spring

and composite leaf spring made of glass fiber with epoxy resin.

2.2. Steel Leaf Spring

Specification and material properties of the steel leaf spring considered for this present work have been elucidated in Table 1. This spring is of unsymmetrical geometry so the length of the front half spring is 559 mm and theback half spring is 686 mm and leaf is of 50 mm width and 7 mm thickness.

2.3. Composite Leaf Spring

Different kinds of composite leaf spring have been produced depending upon different type of automobiles that have leaf springs and different loading conditions. In some spring designs, the width and thickness are fixed along longitudinal axis of the spring. In few types, the width is kept constant and thickness is varied along the spring length. In other types, width is fixed and in each section the thickness is varying exaggeratedly so that, at two edges the thicknesses is minimal and in the centre part, it is slightly high. Also, the specification and material properties of the glass fiber epoxy resin composite leaf spring is elucidated in Table 1.

Table 1: Specification and Material Properties for Steel and Composite Leaf Spring

Specification and Material Properties	Steel Leaf Spring	Composite Leaf Spring
Length	1245 mm	1245 mm
Thickness	7 mm	10 mm
Front half	559mm	559mm
Arc height at axle seat	120.5mm	120.5mm
Spring rate	20.77N/mm	20.77N/mm
Normal static loading	2500N	2500N
Full bump loading	4660N	4660N
Available space for spring width	50mm	30mm
Weight	9.1 Kg	2.3 Kg
Young's modulus	210Gpa	38.6Gpa
Poisson ratio	0.3	0.26

2.4. Design and Optimization

In the present scenario, laminated composite materials are used in most of the engineering sectors; optimizing the design and fabrication of laminated composites has become a vital area of researchers. Since the leaf spring made of composites have only one leaf, it is vital to optimize the shape and size of the leaf spring. During selection of optimum geometry, the engineer must make decisions connected to the material properties. This process requires a validation of a wide range of different empirical and most crucial solutions. Thus, optimization of design is processed with the finite element analysis method. For modeling the material of more thickness, curved shape and orthotropic structures a 3D brick element can be used in ANSYS software. Meanwhile, 3D shell elements can be used for material of slender structures. In the center part of the composite spring, the thickness will be more to prevent the maximum bending load applied. Instead of the brick elements, shell elements can be used which require amore number of elements to correspond an actual model of the composite spring and accordingly the computing time will also increases. For the unidirectional lay up of glass fiber epoxy resin composite leaf spring, a 3D 8 nodded brick element should be chosen to develop a FEM of the composite leaf spring. Figure 1 shows the meshed leaf spring before the stress analysis. The stress distribution for the steel and the glass fiber with epoxy resin composite leaf spring is shown Figure 2 and Figure 3 respectively.

2.5. Stress Analysis in the Spring

Under bending load condition, the leaf spring is analyzed and the normal induced stresses are vital, because the composite materials properties that are anisotropic in nature, the other components of the stress tensor should be taken into consideration. In this analysis, the longitudinal compression strength of the composite is smaller than the longitudinal tensile strength, so fracture will take place at the compression surface of the spring. Thus the stress analysis for smaller area is taken into contemplation.

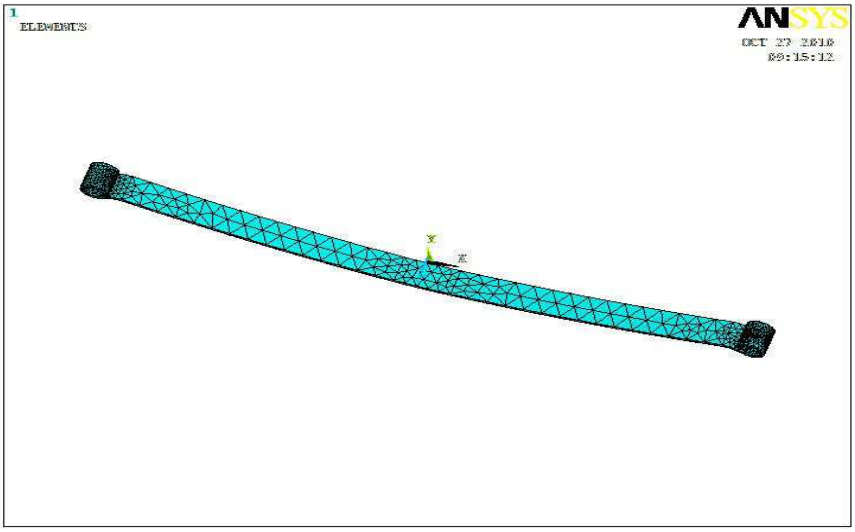

Figure 1: Finite Element Meshing of Leaf Spring

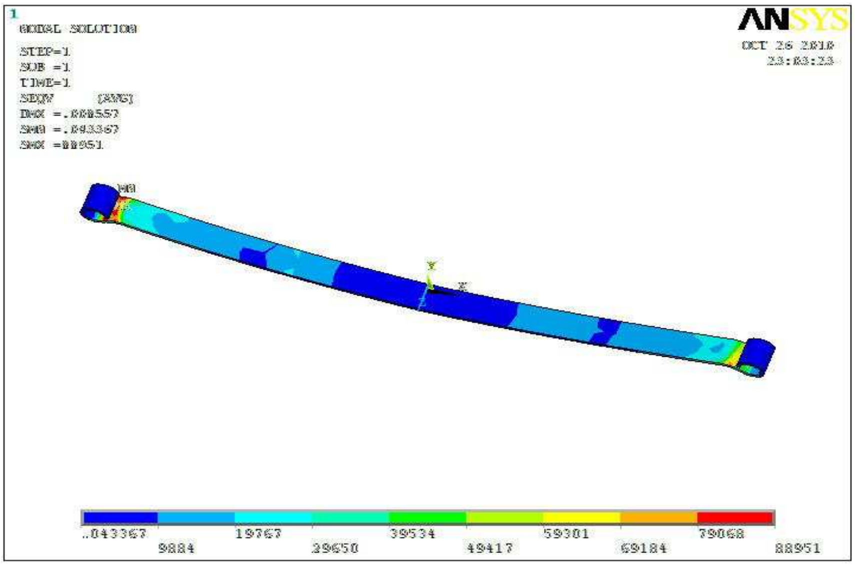

Figure 2: Stress Distribution for Leaf Spring Made of Steel

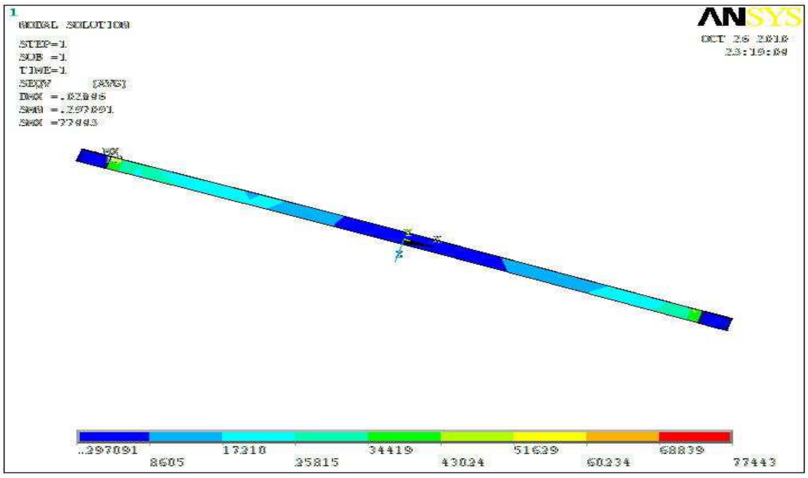

Figure 3: Stress Distribution for Glass Fiber with Epoxy Resin Composite Leaf Spring

3. CONCLUSIONS

A leaf spring made of steel, which is used in the back suspension of light passenger vehicles were analyzed by the analytical and the FEM. The experimental results along with the finite element solutions were verified during analysis. The steel leaf spring after proper investigation was replaced with an optimized glass fiber with epoxy resin composite leaf spring. The main considerations were given for optimizing the geometry of the leaf spring. From the results, for the composite leaf spring, the optimum spring width decreases exaggeratedly and the thickness of the spring increases straightly from spring eye towards the axle seat. The induced stresses produced in the composite leaf spring are much lower than the stress in the steel spring. The weight of the steel leaf spring is 9.1 kg, but the optimal leaf spring made of composites without eye units' weights 79% less than that of the steel spring.

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